*Lecture*

# Module 4: Introduction to Soils and Soil-Landscape Relationships

**Eugene F. Kelly**
**Department of Soil and Crop Sciences**
**Colorado State University**

## Learning Objectives

Upon completion of this module, the participant will be able to:

1. List key soil physical and chemical properties of soil and explain how they influence components of the landscape.

2. Explain how landscape processes affect soils.

3. Recognize and interpret major geomorphological processes

## Lecture Outline

The "duality" of soils:

Soils ***reflect*** the primary climatological, geological, biological, and topographical conditions. The properties of the soil that regulate water and gas exchange with the atmosphere and influence plant growth have important ***effects*** on the environment.

C. Rewa

1. Soil Forming Factors
    - climate
    - organisms
    - parent material
    - time
    - relief
    - humans (cultivation/land use)

2. Water Movement on Landscapes

3. Soil Forming Processes
    - General categories for soil forming processes
        - Additions of materials to soils
        - Removals (loss) of material from soils
        - Translocations (transport) of materials within soils
        - Transformations of materials within soils

4. Key Soil and Ecosystem Properties that Vary with Topography
    - Plant production
    - Decomposition
    - Erosion
    - Deposition
    - Leaching

5. Key Soil Properties
    - Physical Properties
        - Textures
        - Bulk Density
        - Depth to Bedrock
        - Aggregate Stability
        - Soil Color
    - Chemical Properties
        - Organic Matter
        - Soil pH
        - Soil Salinity
        - Cation Exchange
    - Hydrological Properties
        - Drainage
        - Plant available water content
        - Soil Infiltration rate -
        - Permeability (Water Table Depth)

6. Landscapes and Soil Properties

7. Soil Landscapes from Various Climatic Environments
    - Humid Temperate

Humid Tropical
Arid Temperate
Arid Tropical

## Exercises

You will need a copy of a locally published Soil Survey Report to complete this exercise.

Soil surveys are powerful documents that provide generalized information on the quality and distribution of soil resources as controlled by climate, landform, topography, hydrology, geology, biology and age of the land surface. Soil surveys are commonly made at scales of 1:15,000, 1:20,000 or 1:30,000 depending on objectives of the survey, landform characteristics, land use, and expected soil interpretations at the time of survey preparation. Soil surveys have an average half-life of 15-20 years because of changes in soil concepts, changes in soil behavior, modifications of cultural features and, perhaps most importantly, changes in land use.

A. Read the section of your local Soil Survey Report entitled "The Nature of the Survey Area." This will give you very general information about the soil forming factors of your survey area.

    1. What are the major soil forming factors for this area?

    2. What is the general geology of the area?

    3. List MAP, MAT, MAST.

B. Go to the detailed soil maps and find the closest section to your present location.

1. What are the major soil types within this quad?

2. List the soil series names and soil classification for each (see table of classification of soils in report).

3. Based on the soil map, what is the major landform within this quad?

C. Identify the dominant soil series for your specific location. Review the Soil Quality Test Kit covered in Module 1 for hints.

1. Look at the soil! Does this soil match the soil identified on the map? If not, how does the soil you are observing differ from the soil identified on the map? Wetter, Drier, Darker, Lighter, Deeper, Shallower etc…

2. What role might topography play in the differences you have noted?

## Study Questions

1. Describe three ways soil carbon changes as a reflection of environmental conditions.

2. Explain how soils affect the environment.

3. Considering topography and soils, how does precipitation affect the different parts of a hillside?

## References and Selected Reading

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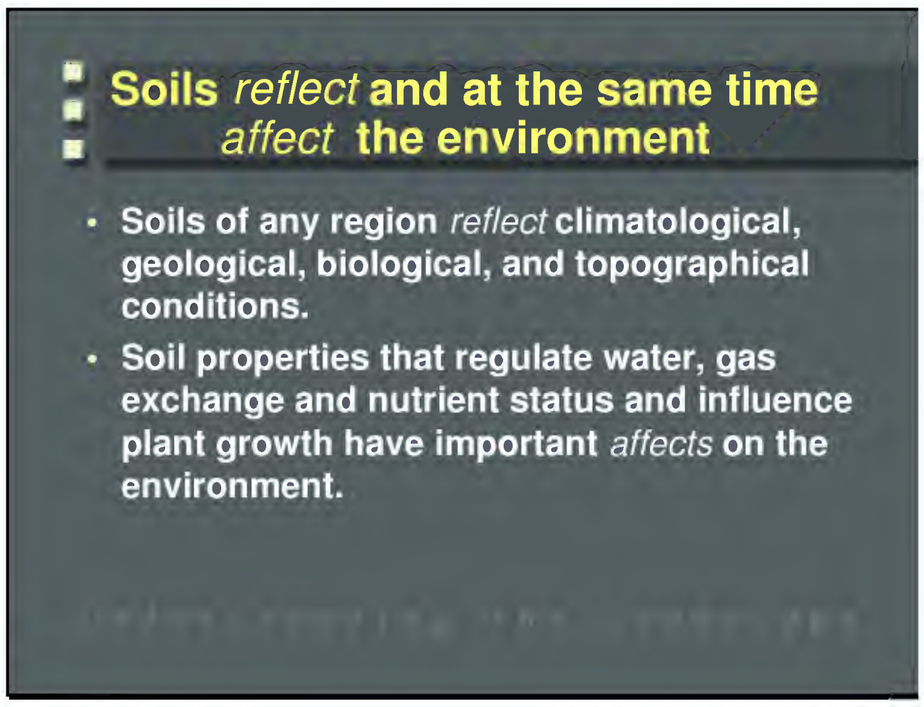
## Slides used in lecture

Slide 1

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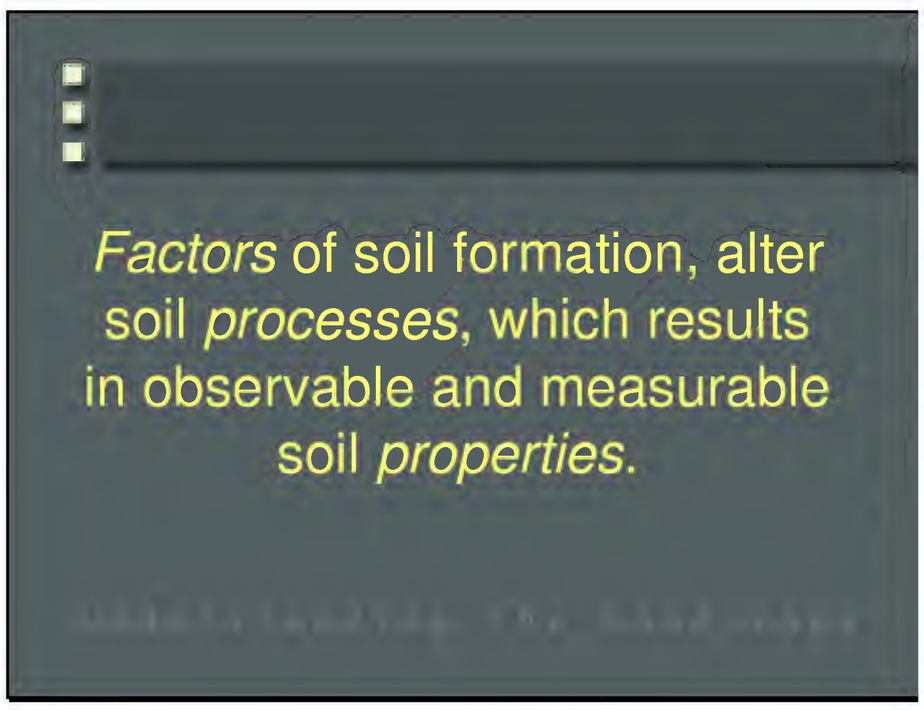


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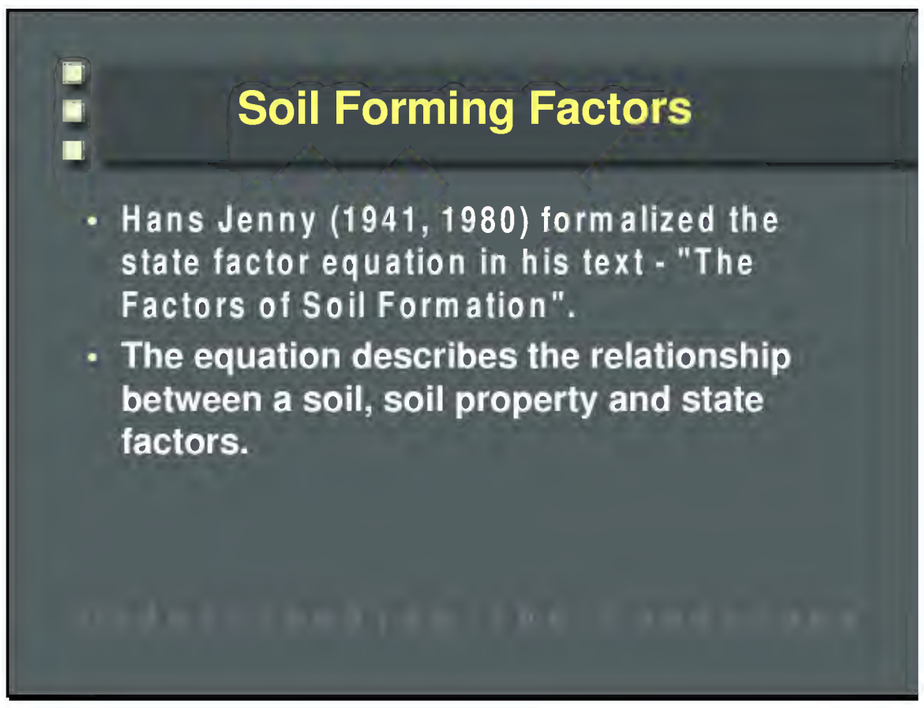

Slide 4

## State Factor Equation

S = f (cl, o, r, p, t ...)

where,

S = Soil or any soil property
cl = climate
o = organisms
r = relief
p = parent material
t = time
h = humans

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## Application of State Factor Approach

- The relationship between any state factor and a given soil property may be viewed experimentally by isolating one variable.
- The state factor approach allows for a quantitative assessment of soil properties as a function of these conditioning variables.

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## $S = f(cl)_{o, r, p, t,...}$

- This is a mathematical expression for soil or a soil property as a function of climatic conditions.
- The significance of climate can be most easily quantified by studying a *sequence* of soils in which only climate varies. This is termed a "climosequence".

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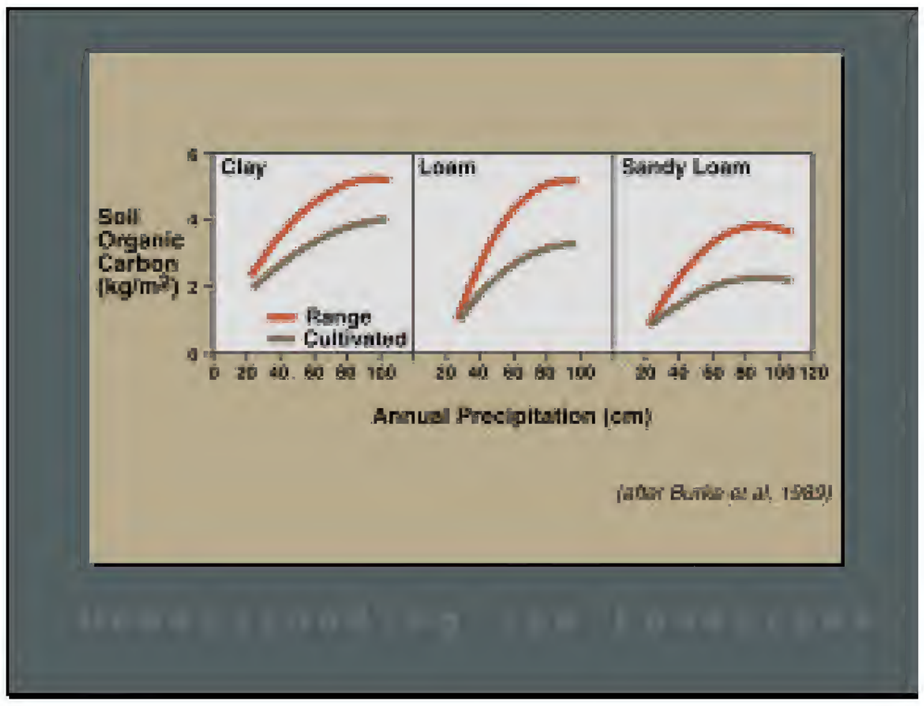


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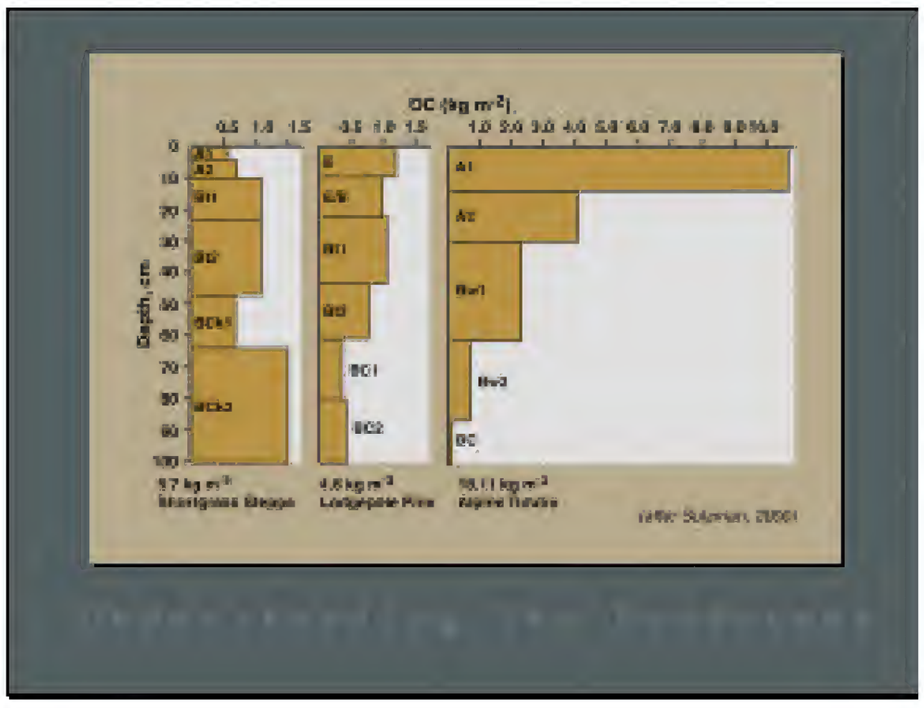


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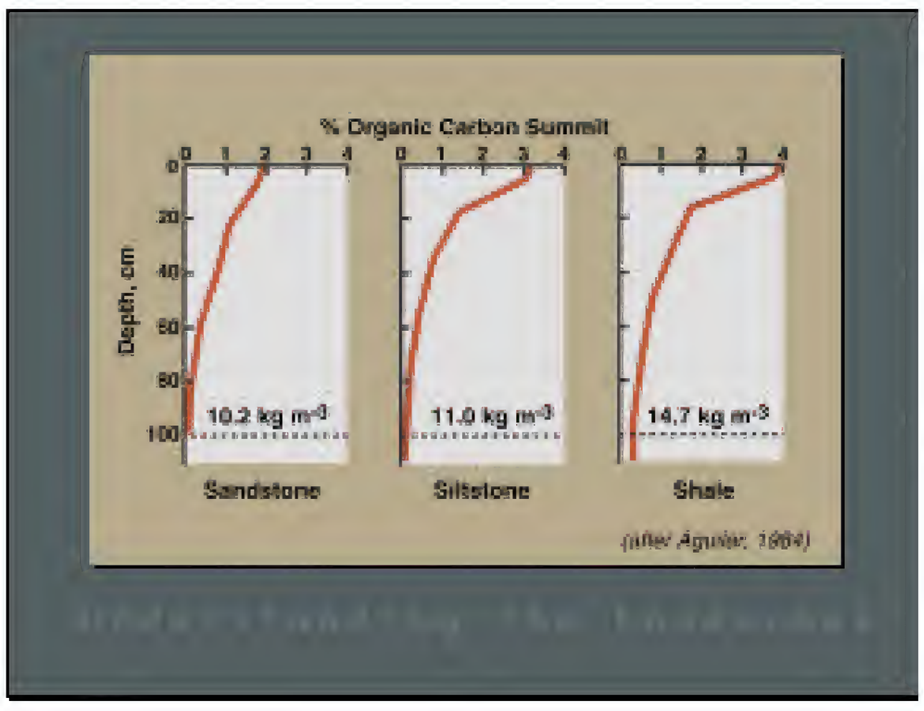

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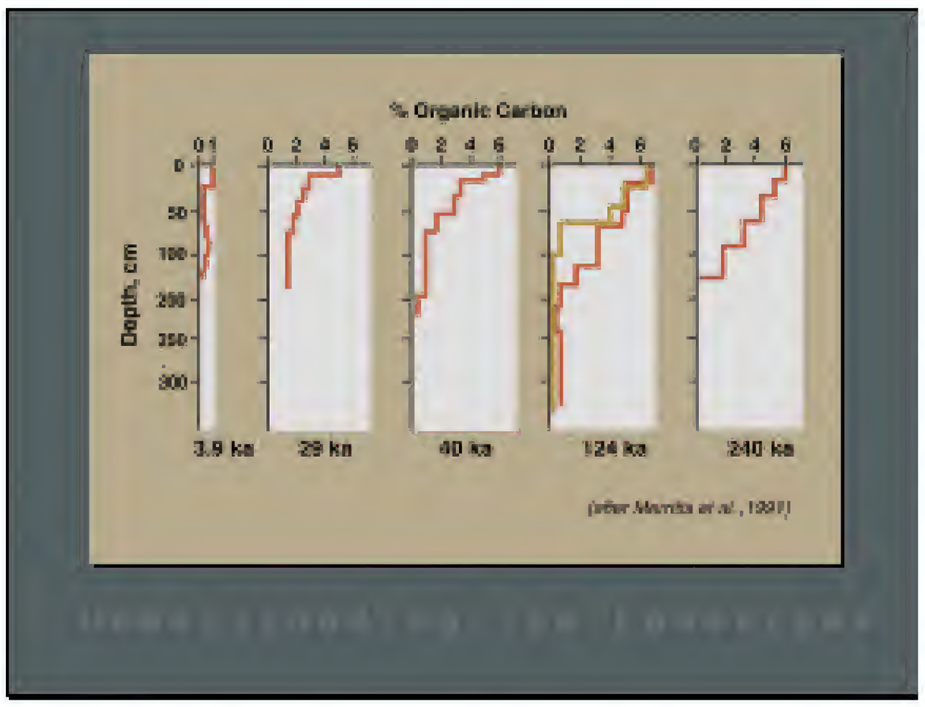


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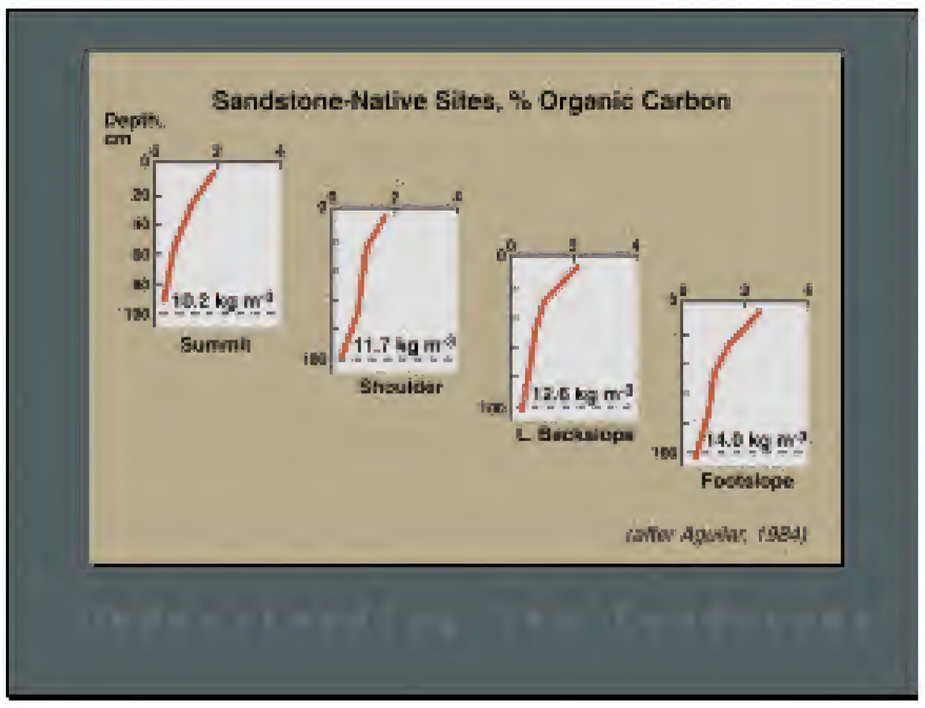


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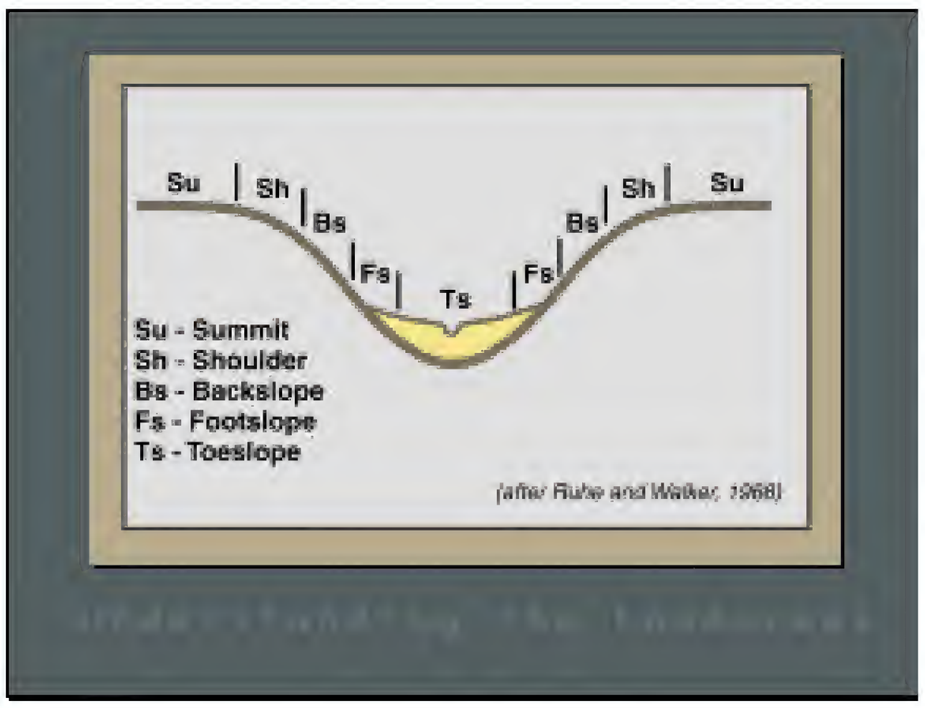

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## Components of Hillslopes

- Summit - linear slopes, vertical water movement, uniform soil material, usually well drained
- Shoulder - steep convex slopes, maximum runoff, soil and subsurface water movement

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## Components of Hillslopes

- Backslope - linear slopes, surface and subsurface transport of soil and water
- Footslope - concave slopes, additions of moisture through surface and subsurface flow
- Toeslope - concave to linear slopes, deposition of soil and organic material, high water table

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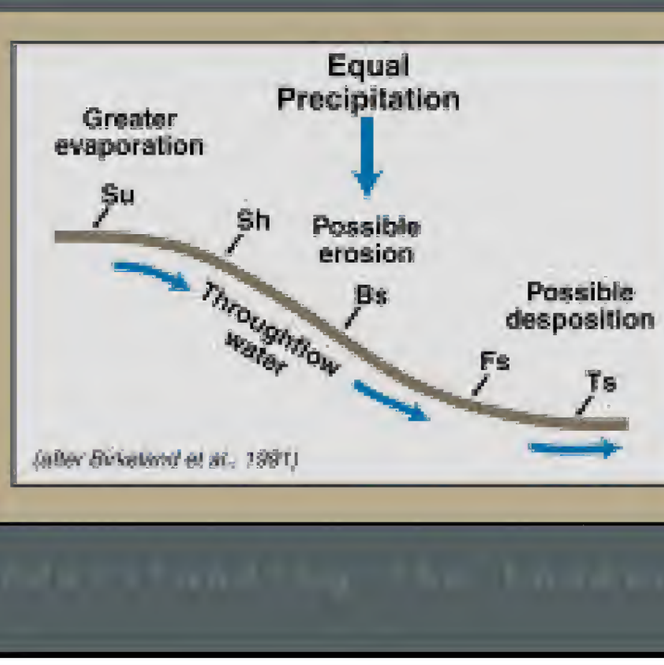

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## Water Movement on Landscapes

- The distribution of water on slopes has a fundamental control on the nature of soils.
- Water movement integrates soils existing on different parts of the landscape and is governed by a complex set of interrelated landscape properties.

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## Water movement across landscapes is governed by

- External variables - rainfall duration and intensity
- Intrinsic properties - soil texture, vegetation type, slope form and angle

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## State Factors and Ecosystems

- Properties of the total ecosystem or its component parts (soil) are dependent on, related to, or conditioned by these state factors.
- State factors provide a conceptual framework for the study and evaluation of natural systems.

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## Soil Forming Processes

- Additions
- Removals
- Translocations
- Transformations

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## Additions to the Soil

- Organic materials - includes deposition of plant and animal remains
- Inorganic materials - material added to soil through both wet and dry deposition

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## Removals from the Soil

- solids – removal primarily by the process of *erosion*
- liquids - removal of material dissolved in water is primarily accomplished by *leaching, evaporation* and *transpiration* processes
- gases - when the concentration of certain gases exceeds the concentration in the atmosphere they leave the soil through *diffusion* processes

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## Translocations within the Soil

- solids - both organic and inorganic materials are transported from the upper (near surface) to the lower (deeper) portions of the soil
- liquids - dissolved constituents are carried along with water and can precipitate in lower portions of the soil

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## Soil Chemical Properties

- Organic Matter Content - provides a generalized indication of the relative fertility status of the soil; promotes greater water retention, aeration, fertility
- Soil pH - an index of the relative acidity or alkalinity of the soil; often considered a master variable in determining the nutrient availability of a soils

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## Chemical Properties (Continued)

- Soil Salinity - an index of salt content; salts in large quantities may inhibit the plant's ability to extract water and nutrients from the soil
- Cation Exchange Capacity - relative measure of the soil's potential to retain added nutrients; soils with high CEC have a greater nutrient retention potential than soils with a low CEC

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## Soil Hydrological Properties

- Plant available water content - an index that relates to the amount of soil water available for plant use immediately after wetting
- Soil infiltration rate - rate at which water enters the soil surface; is highly dependent on soil physical properties such as soil texture.

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## Hydrological Properties (Continued)

- Permeability - the ability of the soil to transmit water through and below the rooting zone
- Water table depth - provides a generalized estimate of the depth to standing water over a small geographic area

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## Landscapes and Soil Properties

- Landscapes and landscape components display systematic differences in soil properties as soil forming processes are modified by relief

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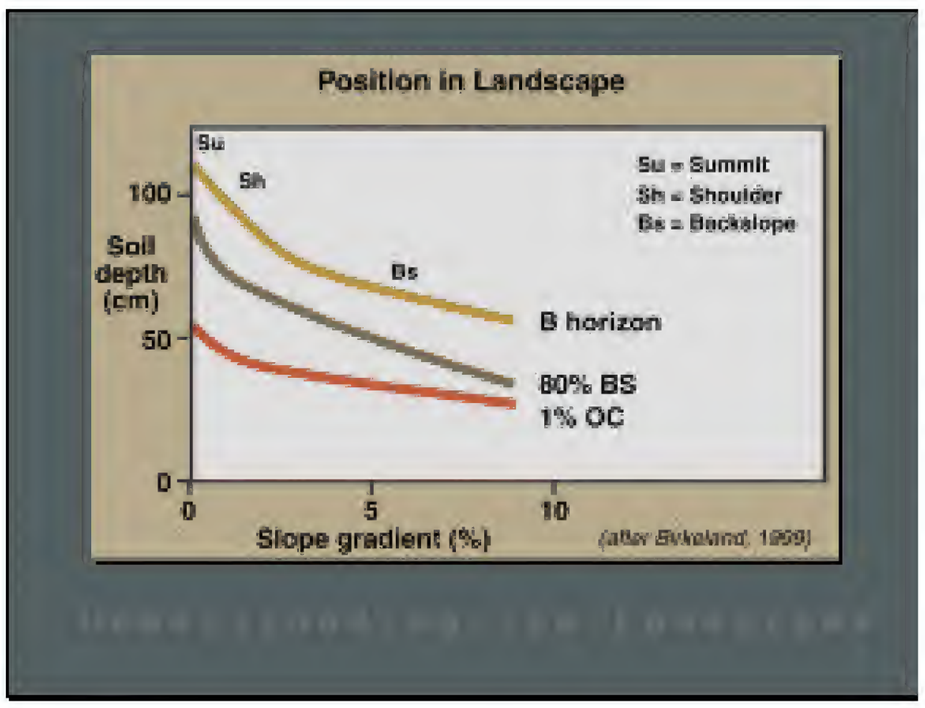


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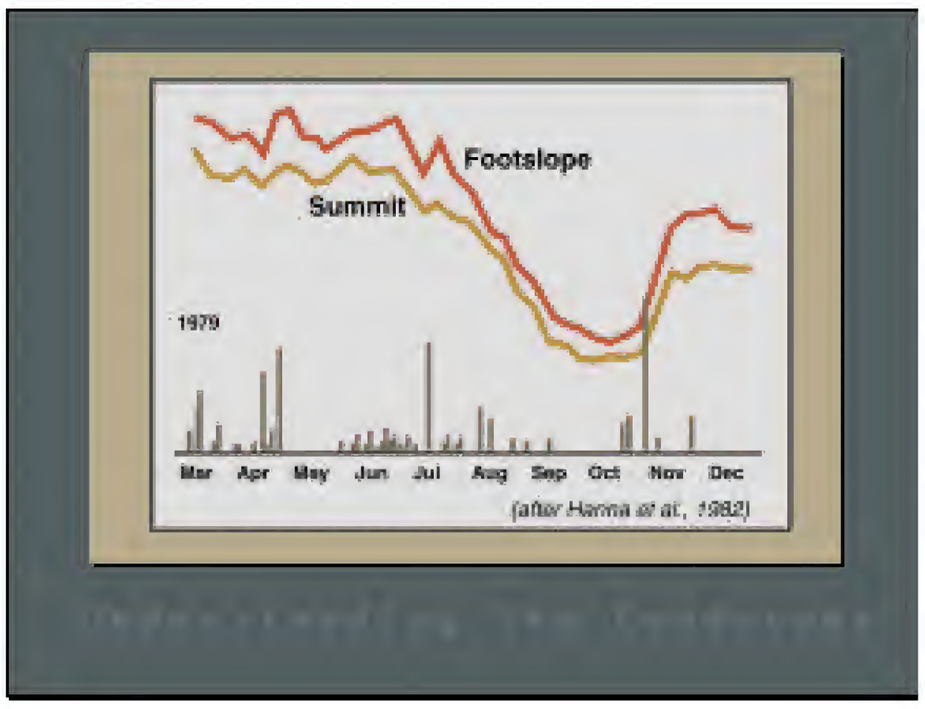


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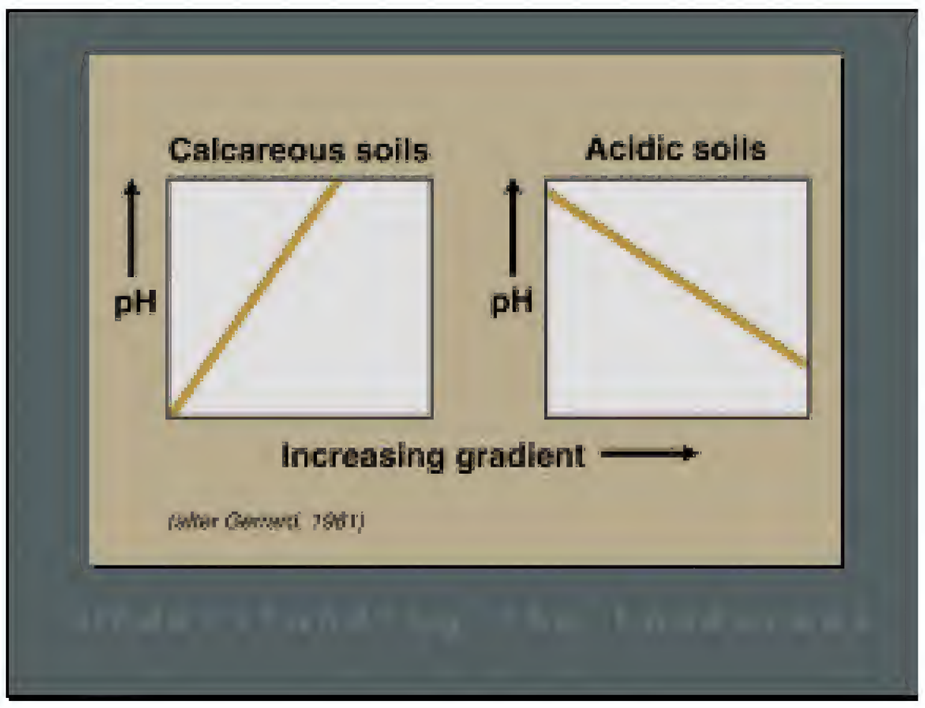

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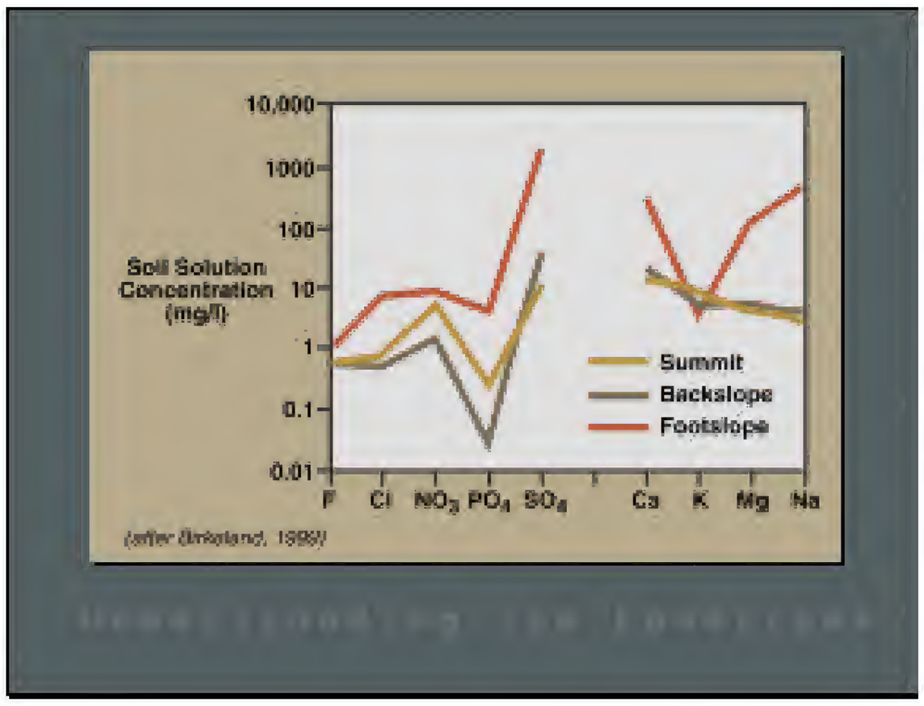


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The degree to which soils and soil properties vary within landscapes is predictable based on an understanding of the fundamental factors and processes of soil formation.

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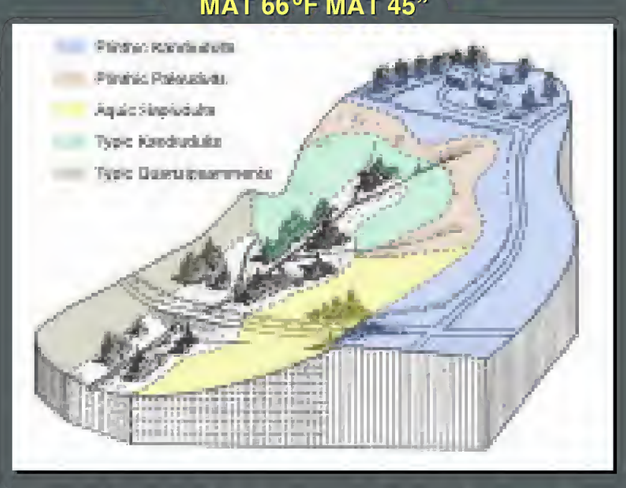
Hot/Wet
Treutlen County, Georgia
MAT 66$^0$F MAT 45”



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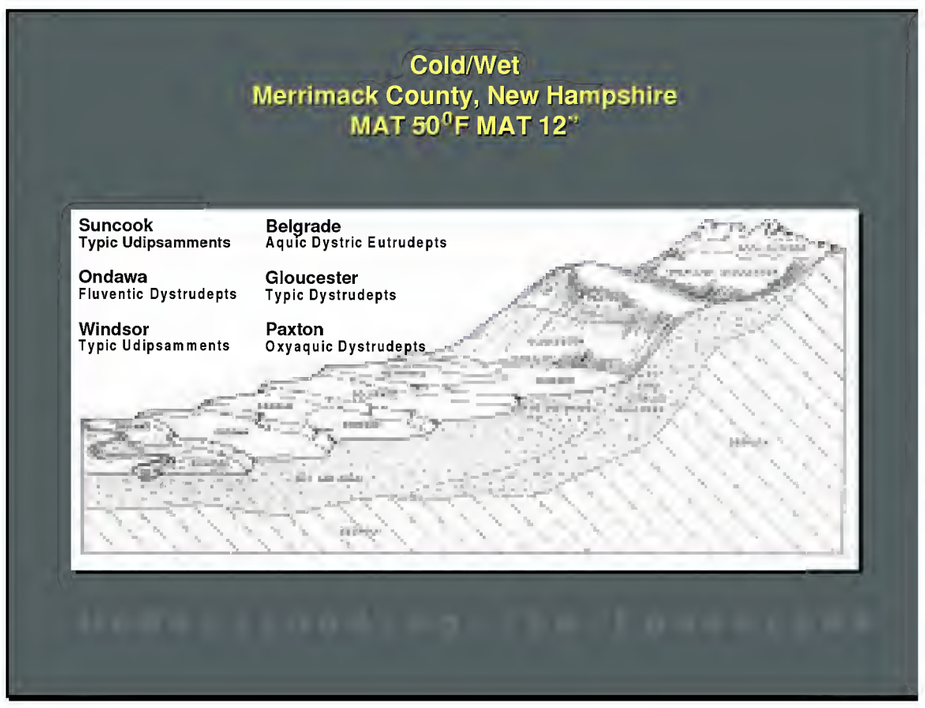


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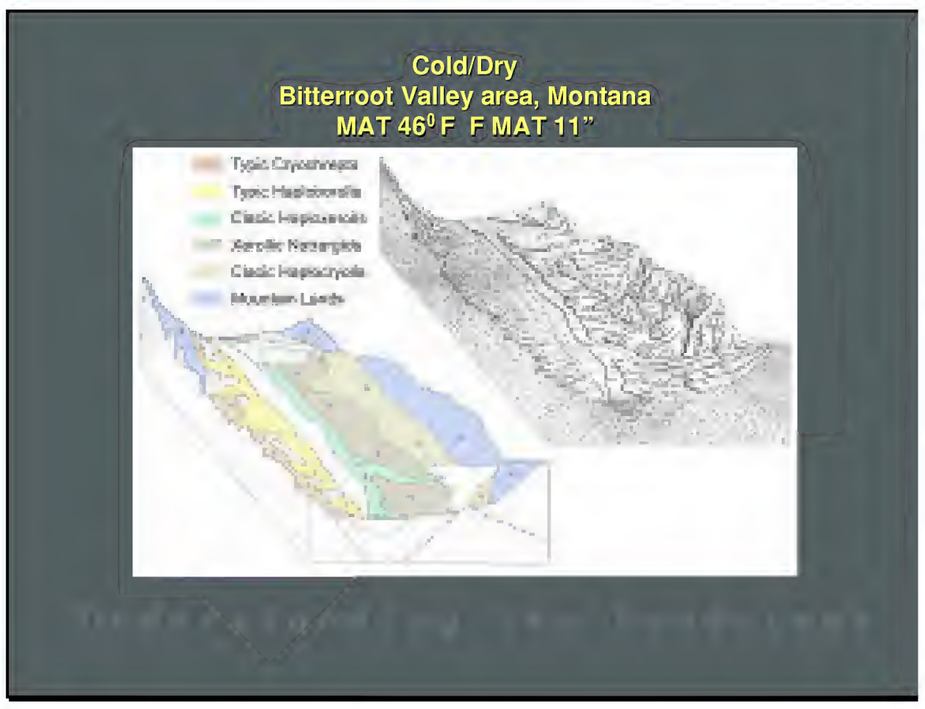


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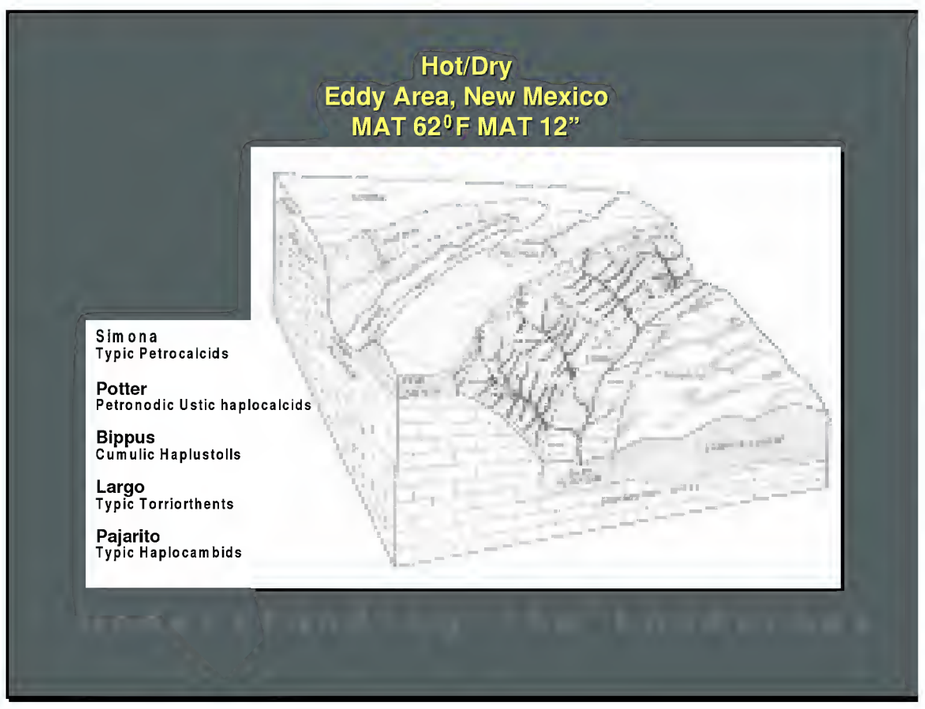

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## Summation

- The need to understand the distribution of soil properties and soil behavior indeed is imperative to the management of both natural and agricultural ecosystems
- Landscape units display systematic differences in soil properties as a function of relief modifying the major soil forming processes for any individual region